

1 **Effects of priming and pacing strategy on $\dot{V}O_2$**
2 **kinetics and cycling performance**

3

4 Original Investigation

5

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30 **ABSTRACT**

31 **Purpose:** To assess whether combining prior ‘priming’ exercise with an all-out pacing
32 strategy was more effective at improving O₂ uptake (\dot{V}_{O_2}) kinetics and cycling performance
33 than either intervention administered independently. **Methods:** Nine males completed target-
34 work cycling performance trials using a self-paced or **all-out** pacing strategy with or without
35 prior severe-intensity (70%Δ) priming exercise. Breath-by-breath pulmonary \dot{V}_{O_2} and
36 cycling power output were measured during all trials. **Results:** Compared to the self-paced-
37 unprimed control trial (22 ± 5 s), the \dot{V}_{O_2} mean response time (MRT) was shorter (\dot{V}_{O_2}
38 kinetics was faster) with all-out pacing (17 ± 4 s) and priming (17 ± 3 s), with the lowest \dot{V}_{O_2}
39 MRT observed when all-out pacing and priming were combined (15 ± 4 s) ($P < 0.05$).
40 However, total O₂ consumed and end-exercise \dot{V}_{O_2} were only higher than the **control**
41 condition in the primed trials ($P < 0.05$). Similarly, cycling performance was improved
42 compared to **control** (98 ± 11 s) in the self-paced-primed (93 ± 8 s) and all-out-primed (92
43 ± 8 s) trials ($P < 0.05$), but not the all-out-unprimed trial (97 ± 5 s; $P > 0.05$). **Conclusions:**
44 These findings suggest that combining an **all-out** start with severe-intensity priming exercise
45 additively improves the \dot{V}_{O_2} MRT, but not total O₂ consumption and cycling performance
46 since these were improved by a similar magnitude in both primed trials relative to the self-
47 paced-unprimed control condition. Therefore, these results support the use of priming
48 exercise as a pre-competition intervention to improve oxidative metabolism and performance
49 during short-duration high-intensity cycling exercise, independent of the pacing strategy
50 adopted.

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52 **Key Words:** Pulmonary \dot{V}_{O_2} , warm-up exercise, fast/all-out start, near-infrared
53 spectroscopy, exercise performance

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67 INTRODUCTION

68 Cycling performance is a function of the power required to overcome resistive forces (e.g.,
69 air and rolling resistance) and power generation from the contracting skeletal muscles.¹⁻² The
70 potential of the skeletal muscles to maintain a high power output is influenced by the energy
71 contribution from aerobic and anaerobic metabolism.³⁻⁴ Whilst oxidative ATP turnover
72 increases exponentially following the onset of exercise, muscle ATP demand increases
73 immediately, which mandates an important energy contribution from anaerobic metabolism
74 in the initial stages of exercise.⁵ At a given rate of ATP turnover, speeding the rate at which
75 pulmonary oxygen uptake (\dot{V}_{O_2}) increases over the initial stages of exercise would be
76 expected to attenuate the reliance on the finite anaerobic energy reserves and blunt the
77 accumulation of metabolites linked to the process of muscle fatigue.⁵ Therefore,
78 interventions that enhance pulmonary \dot{V}_{O_2} kinetics would be hypothesised to increase mean
79 skeletal muscle power output during short-duration high-intensity exercise, permitting a
80 higher cycling speed and a faster race completion time.⁶

81
82 Pulmonary \dot{V}_{O_2} rises with more rapid overall response kinetics after prior ‘priming’ exercise
83 compared to control⁷⁻⁹ and also when exercise is initiated with a fast-start or all-out strategy
84 compared to even-start and slow-start strategies.¹⁰⁻¹⁵ Moreover, performing priming exercise
85 prior to,⁹ or adopting fast-start or all-out pacing strategies during,^{11,15} very high work rates
86 where fatigue ensues before the peak \dot{V}_{O_2} ($\dot{V}_{O_{2peak}}$) can be attained (i.e., extreme-intensity
87 exercise),¹⁶ increases the percentage of the $\dot{V}_{O_{2peak}}$ that can be achieved. In addition to
88 improving aspects of \dot{V}_{O_2} kinetics, priming exercise and fast-start or all-out pacing strategies
89 have been shown to improve exercise tolerance^{7,9,14} and performance.^{8,10-12,15,17-22} Since the
90 use of prior ‘warm up’ exercise and fast-start strategies are recommended as interventions to
91 enhance \dot{V}_{O_2} kinetics and athletic performance,²³ understanding if and how priming exercise
92 and different pacing strategies interact might help inform best practice for optimizing
93 exercise performance.

94
95 The purpose of this study was to investigate whether combining prior severe-intensity
96 priming exercise with an all-out pacing strategy would have an additive effect on the
97 improvements in performance and \dot{V}_{O_2} kinetics that have been reported when either of these
98 interventions is applied independently. We hypothesised that, compared to a self-paced-
99 unprimed control condition, time-trial performance, \dot{V}_{O_2} kinetics, total O₂ consumption and
100 the percentage of $\dot{V}_{O_{2peak}}$ attained would be improved by a similar extent in a self-paced-
101 primed trial and an all-out-unprimed trial, but that the greatest improvement in these
102 parameters would occur when severe-intensity priming exercise and an all-out pacing
103 strategy were combined.

105 METHODS

106 *Subjects*

107 Nine competitive male athletes (mean \pm SD: age 20 \pm 1 yr, stature 1.82 \pm 0.06 m, body mass
108 77 \pm 8 kg) volunteered to participate in this study. The study was approved by the University
109 of Exeter Research Ethics Committee and all subjects were required to give their written
110 informed consent prior to the commencement of the study. Subjects were instructed to arrive
111 at the laboratory in a rested and fully hydrated state, at least 3-h postprandial, and to avoid
112 strenuous exercise in the 24-h preceding each testing session.

114 *Experimental Overview*

115 The subjects were required to report to the laboratory on seven occasions over a 4-5-week
116 period with the seven visits being separated by at least 48-h. Following the completion of

117 preliminary exercise tests, all subjects completed four exercise performance trials (visits 4-7)
118 during which pulmonary \dot{V}_{O_2} , blood [lactate], muscle (de)oxygenation and exercise
119 performance were assessed. To determine a potential interaction between pacing strategy and
120 priming exercise on performance and the physiological responses during exercise, we
121 employed a paradigm comprising two different pacing strategies (**self-paced** and **all-out**) that
122 were completed with and without priming exercise.

124 ***Incremental Test***

125 On the first laboratory visit, subjects completed a ramp incremental cycling test for
126 determination of the $\dot{V}_{O_{2peak}}$, gas exchange threshold (GET) and the work rate that would
127 require 70% Δ (GET plus 70% of the difference between the work rate at the GET and \dot{V}
128 O_{2peak}) as described previously.⁷

130 ***Familiarization Trials***

131 During the first familiarization trial (visit 2), subjects were familiarised to the ‘standing’ start
132 and were required to complete three 40 kJ trials lasting approximately 100-s. The resistance
133 on the pedals during the trials was set for each individual using the linear mode of the Lode
134 ergometer so that the subject would attain the power output associated with 70% Δ on
135 reaching their preferred cadence (linear factor = power/preferred cadence²). Subjects were
136 provided with a 5-s countdown prior to the commencement of all cycling trials. In addition
137 to a warm up, the first trial was used to familiarize subjects to the fixed resistance that would
138 be imposed in all subsequent trials. In this first trial, subjects were instructed to complete the
139 40 kJ warm up by cycling at a submaximal cadence of 70-90 rpm. Following a 10-min
140 passive recovery period, subjects repeated the 40 kJ trial but, on this occasion, they were
141 instructed to complete the 40 kJ in the fastest time possible using a self-selected pacing
142 strategy. Following a further 25-30-min passive recovery, subjects completed a third 40 kJ
143 trial using an ‘all-out’ pacing strategy. The power output was continuously recorded at 5-Hz
144 during these trials and averaged into 1-s bins for subsequent analysis. To estimate the work
145 required for a completion time of 100-s for each individual subject, the mean power output
146 during the **self-paced** trial was multiplied by 100. This individualized work target was set
147 during all subsequent experimental trials in an attempt to yield a completion time reflective of
148 a 1000-m track cycling performance for a trained but sub-elite cyclist.²⁴

150 During the second familiarization trial, subjects were familiarized to the priming exercise
151 protocol and completed two additional trials at their individualized work target. The priming
152 exercise protocol comprised 4-min of baseline cycling at 20 W before an abrupt transition to
153 the severe-intensity target work rate (70% Δ). The severe-intensity priming bout was 5-min
154 in duration. Following a 17-min passive recovery, subjects remounted the cycle ergometer
155 and rested for an additional 3-min. **This priming regime was selected since it has been shown
156 to be particularly effective at improving performance during subsequent high-intensity
157 cycling exercise.**⁷ Subjects then completed their individualized work target as quickly as
158 possible using a self-paced pacing strategy. Following 25-30-min passive recovery, subjects
159 completed a third performance trial using an ‘all-out’ pacing strategy. Therefore, all subjects
160 completed 5 repetitions of the performance trial and one repetition to the priming bout prior
161 to the experimental testing.

163 ***Experimental Trials***

164 In a randomized order, subjects completed self-paced **and all-out** trials with and without
165 severe-intensity priming exercise over four separate experimental trials. Subjects were
166 instructed to complete each trial as quickly as possible. Each trial was preceded by 3-min of

167 resting baseline on the cycle ergometer. Ten seconds prior to the commencement of each
168 trial, subjects were instructed to adjust the crank angle to their preferred starting position,
169 which was established in the familiarization trials and replicated in all experimental trials,
170 and to assume a standing position on the cycle ergometer. Subjects were then provided with
171 a 5-s countdown to indicate when the trial would commence. For the initial 10-s of the trial,
172 subjects were required to cycle in the upright position before being instructed to assume a
173 seated position for the remainder of the trial. Subjects were made aware of their work target
174 prior to each trial and the work target and accrued work during the trial was displayed on a
175 computer screen placed directly in front of the subject. Strong verbal encouragement was
176 provided during all trials, but subjects were not aware of the elapsed time during the trials.

177

178 **Measurements**

179 All cycle tests were performed on an electrically-braked cycle ergometer (Lode Excalibur
180 Sport, Groningen, the Netherlands). During all tests, pulmonary gas exchange and ventilation
181 were measured breath-by-breath using an online gas analyzer (Jaeger Oxycon Pro,
182 Hoechberg, Germany), muscle oxygenation variables (deoxygenated hemoglobin
183 concentration [HHb], oxygenated hemoglobin concentration [O₂Hb], total hemoglobin
184 concentration [Hb_{tot}] and tissue oxygenation index (TOI)) were measured using near-infrared
185 spectroscopy (model NIRO 300, Hamamatsu Photonics KK, Hiugashi-ku, Japan) and a blood
186 sample was collected from a fingertip into a capillary tube 30-s prior to the commencement
187 of the trial and immediately following the trial for blood [lactate] determination (YSI 1500,
188 Yellow Springs Instruments, Yellow Springs, OH, United States), as described previously.¹¹

189

190 **Data Analysis Procedures**

191 Prior to analysis the breath-by-breath \dot{V}_{O_2} data from each test were treated as described
192 previously.¹¹ A single-exponential model without time delay, with the fitting window
193 commencing at $t = 0$ s (equivalent to the mean response time, MRT) was used to characterize
194 the kinetics of the overall \dot{V}_{O_2} response during the trials as described in the following
195 equation:

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$$197 \dot{V}_{O_2}(t) = \dot{V}_{O_2 \text{ baseline}} + A(1 - e^{-t/\text{MRT}}) \quad (\text{Eqn. 1})$$

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199 where $\dot{V}_{O_2}(t)$ represents the absolute \dot{V}_{O_2} at a given time t ; $\dot{V}_{O_2 \text{ baseline}}$ represents the mean \dot{V}_{O_2}
200 measured over the final 90-s of baseline; and A and MRT represent the amplitude and MRT ,
201 respectively, describing the overall increase in \dot{V}_{O_2} above baseline. An iterative process was
202 used to minimize the sum of the squared errors between the fitted function and the observed
203 values. We quantified the \dot{V}_{O_2} MRT with the fitting window constrained to both completion
204 time (end-exercise) and at the minimum completion time for each subject across the four
205 experimental trials (T_{min}). The absolute \dot{V}_{O_2} at, and the total O₂ consumed up to, 60-s (± 5 -s),
206 end-exercise (average over the final 10-s) and T_{min} (average over the final 10-s) were also
207 calculated. We also divided the total O₂ consumed up to 60-s by the work accumulated over
208 the corresponding time frame to provide an indication of the oxidative energy provision
209 relative to external power output.

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211 The [HHb] kinetics during the exercise bouts was determined by fitting a mono-exponential
212 model with a time delay (TD) from the first data point which was 1 SD above the baseline
213 mean. The [HHb] TD and τ values were summed, to provide information on the overall
214 [HHb] response kinetics. We quantified the [HHb] kinetics during the trials using three
215 different fitting procedures: 1) the fitting window was constrained to the point at which
216 mono-exponentiality became distorted, consequent to a gradual fall in [HHb], as determined

217 by visual inspection of the residual plots data (peak fit); 2) the fitting window was
218 constrained to T_{\min} (T_{\min} fit); and 3) the HHb data were fit to end-exercise (end-exercise fit).
219 The [HHb], [O₂Hb], [Hb_{tot}] and TOI values at baseline (average over the 90-s preceding the
220 onset of the trial), 20-s (\pm 5-s), 60-s (\pm 5-s) and end-exercise (average over the final 10-s)
221 were also calculated.

222

223 Performance during the fixed work trial was determined by the time required to complete the
224 designated work target. Peak power output during the trials was taken as the highest 1-s
225 power output during the trial and end-exercise power output was taken as the average power
226 output over the final 10-s of the trial.

227

228 ***Statistical Analysis***

229 A two-way (pacing x priming) repeated-measures ANOVA was employed to determine the
230 effects of pacing strategy and priming exercise on the relevant physiological and performance
231 variables. Where the analysis revealed a significant difference, individual paired *t*-tests were
232 employed with a Fisher's LSD to determine the origin of such effects. All data are presented
233 as mean \pm SD. Statistical significance was accepted when $P < 0.05$.

234

235 **RESULTS**

236 During the ramp incremental test, subjects attained a peak work rate of 370 ± 45 W and a \dot{V}
237 $O_{2\text{peak}}$ of 4.18 ± 0.56 L \cdot min⁻¹. The work target for the performance trials was 41.3 ± 4.8 kJ
238 and the work rate applied during the severe-intensity priming bout was 273 ± 37 W.

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240 ***Blood [lactate]***

241 Baseline blood [lactate] was greater in the primed trials ($P < 0.001$; Table 1). End-exercise
242 blood [lactate] was higher in the self-paced-primed and all-out-primed trials compared to the
243 self-paced-unprimed control trial ($P < 0.05$), but not the all-out-unprimed trial ($P > 0.05$; Table
244 1).

245

246 ***Near-infrared Spectroscopy***

247 Baseline muscle [O₂Hb], [Hb_{tot}] and TOI were higher in the primed trials ($P < 0.05$; Table 2).
248 Muscle [O₂Hb] and [Hb_{tot}] were greater during exercise in the primed trials, whereas TOI was
249 higher 20-s into exercise in the primed trials compared to the all-out-unprimed condition
250 ($P < 0.05$; Table 2). Muscle [HHb] $\tau + \text{TD}$ was shorter in both primed trials compared to the
251 self-paced-unprimed control ($P < 0.05$; Figure 1; Table 2).

252

253 ***$\dot{V}O_2$ Kinetics***

254 Compared to the self-paced-unprimed control, the $\dot{V}O_2$ MRT was shorter in all other
255 experimental conditions ($P < 0.05$). Moreover, the $\dot{V}O_2$ MRT was shorter in the all-out-primed
256 compared to the all-out-unprimed and self-paced-primed conditions ($P < 0.05$; Table 3; Figure
257 2). The total O₂ consumed and the total O₂ consumed relative to work done over the first 60-
258 s of exercise were greater in the self-paced-primed and all-out primed trials compared to their
259 respective unprimed conditions ($P < 0.01$; Table 3). In the unprimed trials the end-exercise \dot{V}
260 O_2 was lower than the ramp test $\dot{V}O_{2\text{peak}}$ and the end-exercise $\dot{V}O_2$ during the primed trials
261 ($P < 0.05$), whereas the end-exercise $\dot{V}O_2$ during the primed trials was not different from the \dot{V}
262 $O_{2\text{peak}}$ ($P > 0.05$; Table 3).

263

264 ***Cycling Performance***

265 The peak power output and total work done over the first 60-s were higher in the all-out trials
266 ($P < 0.05$), whereas end-exercise power output was higher with priming ($P < 0.05$; Figure 3).

267 Trial completion time was faster than control (98 ± 11 -s) in the self-paced (93 ± 8 -s) and all-
268 out (92 ± 8 -s; both $P < 0.05$) primed trials, but not with all-out pacing alone (97 ± 5 -s; $P > 0.05$;
269 Figure 4). Completion time was also shorter in the all-out trial after priming compared to the
270 all-out trial without priming ($P < 0.05$).

271 272 **DISCUSSION**

273 The principal original findings from this study are that muscle (de)oxygenation, pulmonary \dot{V}_{O_2}
274 and performance were similar during short-duration high-intensity cycling exercise
275 initiated with a **self-paced** or **all-out** pacing strategy in the unprimed state, but that these
276 variables were enhanced by a similar magnitude when either of these pacing strategies was
277 preceded by a bout of priming exercise. These findings might have important implications
278 for performance enhancement in short-duration high-intensity events, such as 1000-m track
279 cycling, and suggest that priming exercise is similarly effective at improving muscle
280 (de)oxygenation, pulmonary \dot{V}_{O_2} and cycling performance irrespective of whether an **all-out**
281 or **self-paced** pacing strategy is applied.

282
283 When all-out pacing and priming were combined, the \dot{V}_{O_2} MRT (when modelled to T_{\min}) was
284 12% smaller compared to either intervention administered independently, or 32% smaller
285 than the control trial. The \dot{V}_{O_2} MRT was 23% smaller compared to the control trial with
286 priming or all-out pacing alone. Faster overall \dot{V}_{O_2} kinetics have been reported in previous
287 studies following priming exercise^{7-9,25} and when fast start strategies are employed.^{11,13-15,25}
288 In contrast to the findings of this study, a recent study observed no additive effect of
289 combining heavy-intensity priming and a **fast-start** strategy on the \dot{V}_{O_2} MRT.²⁵ These
290 conflicting findings might be linked to between-study differences in priming intensity and
291 pacing strategies, and the potential for more rapid \dot{V}_{O_2} kinetics with the severe-intensity
292 priming⁷ and **all-out** pacing strategy¹⁵ used in the current study, relative to the heavy-intensity
293 priming and **fast-start** strategy imposed by Caritá et al.²⁵ Nonetheless, despite an additive
294 improvement in the \dot{V}_{O_2} MRT, the total O_2 consumed up to T_{\min} and the \dot{V}_{O_2} attained at end-
295 exercise were higher in both primed trials, but were not different between the two primed
296 trials or between the two unprimed trials. Indeed, subjects were able to attain their $\dot{V}_{O_{2peak}}$
297 (i.e., as measured on the initial ramp test) during the short-duration cycling bouts after
298 priming regardless of pacing strategy employed whereas without priming, they were not. This
299 is consistent with reports that priming exercise permits the attainment of $\dot{V}_{O_{2peak}}$ during
300 extreme-intensity exercise where $\dot{V}_{O_{2peak}}$ is not attained in the unprimed condition.⁹
301 Therefore the attainment of $\dot{V}_{O_{2peak}}$ with priming permitted a greater total O_2 consumption,
302 whereas the faster \dot{V}_{O_2} kinetics with an **all-out** start was not sufficient to increase total O_2
303 consumption as the percentage of $\dot{V}_{O_{2peak}}$ attained was not significantly altered.

304
305 Muscle blood flow at rest and during the initial stages of exercise has been shown to increase
306 after completing intense priming exercise.²⁶⁻²⁷ Our findings of a greater muscle [Hb_{tot}],
307 [O₂Hb] and TOI with priming are compatible with previous reports of improved muscle
308 perfusion and O_2 availability after priming exercise.^{7,26-27} Therefore, enhanced muscle
309 perfusion and O_2 availability in the primed trials might have contributed towards the more
310 rapid \dot{V}_{O_2} kinetics, greater total O_2 consumption and attainment of a greater percentage of $\dot{V}_{O_{2peak}}$
311 compared to the unprimed conditions.^{3,28} However, in addition to greater muscle O_2
312 delivery, enhanced muscle O_2 extraction²⁶⁻²⁷ and faster muscle [HHb] kinetics⁷ have also been
313 previously reported following priming exercise. In line with these findings, muscle [HHb] τ
314 + TD was shorter with priming in this study, suggestive of enhanced fractional O_2 extraction
315 contributing to faster \dot{V}_{O_2} kinetics following priming.²⁹ Therefore, faster \dot{V}_{O_2} kinetics,
316 attainment of a greater percentage of $\dot{V}_{O_{2peak}}$ and greater O_2 consumption after priming

317 exercise in this study are likely to have arisen as a result of a positive interaction between
318 improvements in muscle O₂ supply and O₂ extraction.

319
320 Although total O₂ consumption over the initial 60-s of exercise was greater with priming,
321 changes in total O₂ consumption between the experimental conditions were not proportional
322 to alterations in power output in all conditions. Commencing exercise at a higher power
323 output, as observed when **all-out** pacing strategies are employed, would be expected to
324 promote more rapid increases in aerobic, anaerobic and total ATP turnover rates.³⁰
325 Therefore, while \dot{V}_{O_2} increased more rapidly in the **all-out** trials relative to the self-paced-
326 unprimed trial, this potential for an increased aerobic energy yield in the **all-out** conditions
327 was accompanied by a greater total work done over the initial stages of exercise.
328 Accordingly, the O₂ consumed per unit work, and presumably the proportional aerobic
329 energy contribution, was not significantly different from the self-paced-unprimed trial in
330 either **all-out** trial over the first 60-s of exercise. However, since priming exercise does not
331 increase the total ATP turnover rate in a subsequent bout of exercise at the same absolute
332 work rate²⁶⁻²⁷ and since the pattern of work rate distribution over the first 60-s was similar for
333 primed and unprimed conditions when the same pacing strategy was employed, the total ATP
334 turnover rate and its temporal fluctuation might be expected to be similar between the two
335 **self-paced** trials, and the two **all-out** trials. The O₂ consumed per unit work over the first 60-s
336 was higher after priming (~9% and ~7% for self-paced-primed compared to self-paced-
337 unprimed and all-out-primed compared to all-out-unprimed, respectively). This is suggestive
338 of a greater proportional aerobic energy contribution in the self-paced-primed and all-out-
339 primed trials relative to their respective unprimed conditions. Consistent with this
340 interpretation, intense priming exercise has been shown to increase aerobic ATP turnover and
341 lower anaerobic ATP turnover, without altering the total ATP turnover, during the initial
342 stages of a subsequent bout of intense constant work rate exercise.²⁶⁻²⁷

343
344 Cycling performance was not significantly impacted by the pacing strategy employed in this
345 study in either the primed or unprimed trials. While the \dot{V}_{O_2} MRT was lower in the all-out-
346 unprimed trial compared to the self-paced-unprimed trial, $\dot{V}_{O_{2peak}}$ was not attained in either of
347 these trials and O₂ consumed, and O₂ consumed relative to work done over the first 60-s,
348 were similar between trials. We have previously shown that **fast-start**¹¹ and **all-out**¹⁵ pacing
349 strategies are ergogenic during short-duration high-intensity exercise when \dot{V}_{O_2} kinetics is
350 faster and the percentage of $\dot{V}_{O_{2peak}}$ attained is greater, but not necessarily when \dot{V}_{O_2} kinetics
351 is faster without changes in the percentage of $\dot{V}_{O_{2peak}}$ attained or total O₂ consumed. On the
352 other hand, the total O₂ consumed and O₂ consumption relative to work done over the first
353 60-s were higher, the percentage of $\dot{V}_{O_{2peak}}$ attained was increased and exercise performance
354 was improved with priming when the same pacing strategy was employed. This finding is
355 consistent with previous reports that priming exercise is ergogenic^{7-9,19-21,25}, **particularly when**
356 **baseline blood [lactate] is elevated to 3-4 mM,**^{8-9,11} and suggests that priming might improve
357 short-duration high-intensity exercise performance by increasing the absolute aerobic energy
358 contribution to total energy turnover. **However, since the exercise performance trials in this**
359 **study were conducted in competitive, but not highly trained, athletes in an exercise**
360 **physiology laboratory, further research is required to assess the effects of pacing and prior**
361 **exercise strategies on cycling performance in well-trained cyclists in the velodrome.**

362
363 In conclusion, while \dot{V}_{O_2} kinetics was faster when an all-out pacing strategy was employed,
364 there were no changes in muscle (de)oxygenation, total O₂ consumption, the percentage of $\dot{V}_{O_{2peak}}$
365 attained and cycling performance between these experimental conditions. However,
366 pulmonary \dot{V}_{O_2} and muscle (de)oxygenation kinetics were speeded, total O₂ consumption and

367 the percentage of $\dot{V}_{O_{2peak}}$ attained were increased, and cycling performance was improved in
368 the self-paced-primed and all-out-primed trials compared to their respective unprimed
369 conditions. Therefore, while combining priming with an **all-out** start evoked additive
370 improvements in \dot{V}_{O_2} kinetics, a similar magnitude of improvement in muscle
371 (de)oxygenation variables, total O_2 consumption and short-duration high-intensity cycling
372 performance was observed with priming regardless of the pacing strategy adopted. These
373 findings support the use of prior high-intensity priming exercise as a pre-competition
374 intervention to increase oxidative energy contribution and improve performance in short-
375 duration high-intensity events such as 1000-m track cycling.

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565 **Figure Legends**

566 Figure 1. Near-infrared spectroscopy-derived muscle deoxyhemoglobin concentration
567 ([HHb]) responses in the self-paced unprimed (SP-UP) trial compared to the all-out unprimed
568 (AO-UP) trial (panel A); the self-paced primed (SP-P) trial compared to the all-out primed
569 (AO-P) trial (panel B); SP-UP compared to SP-P (panel C); and AO-UP compared to AO-P
570 (panel D). Data are presented as group mean responses with the baseline normalized to 0 and
571 expressed as the change (Δ) from baseline. The end-exercise muscle [HHb] is presented with
572 y-axis \pm SEM error bars and x-axis \pm SEM error bars for completion time in the performance
573 tests. The dashed vertical lines represent the start of the cycling performance trials. *
574 indicates a significantly longer completion time relative to the respective comparison
575 condition ($P < 0.05$).

576
577 Figure 2. Pulmonary oxygen uptake (\dot{V}_{O_2}) responses in the self-paced unprimed (SP-UP) trial
578 compared to the all-out unprimed (AO-UP) trial (panel A); the self-paced primed (SP-P) trial
579 compared to the all-out primed (AO-P) trial (panel B); SP-UP compared to SP-P (panel C);
580 and AO-UP compared to AO-P (panel D). Data are presented as group mean responses with
581 the end-exercise pulmonary \dot{V}_{O_2} presented with y-axis \pm SEM error bars and x-axis \pm SEM
582 error bars for completion time in the performance test. The dashed vertical lines represent the
583 start of the cycling performance trials. * indicates a significantly longer completion time
584 relative to the respective comparison condition ($P < 0.05$). # indicates significantly higher
585 pulmonary \dot{V}_{O_2} relative to the respective comparison condition ($P < 0.05$).

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587 Figure 3. Cycle ergometry power output responses in the self-paced unprimed (SP-UP) trial
588 compared to the all-out unprimed (AO-UP) trial (panel A); the self-paced primed (SP-P) trial
589 compared to the all-out primed (AO-P) trial (panel B); SP-UP compared to SP-P (panel C);
590 and AO-UP compared to AO-P (panel D). Data are presented as group mean responses with
591 the end-exercise power output presented with y-axis \pm SEM error bars and x-axis \pm SEM
592 error bars for completion time in the performance tests. The dashed vertical lines represent
593 the start of the cycling performance trial. * indicates a significantly longer completion time
594 relative to the respective comparison condition ($P < 0.05$). # indicates significantly higher
595 power output relative to the respective comparison condition ($P < 0.05$).

596
597 Figure 4. Completion times during the target-work cycling trials in the self-paced unprimed
598 (SP-UP), all-out unprimed (AO-UP), self-paced primed (SP-P) and all-out primed (AO-P)
599 conditions. Data are presented as group mean responses with \pm SEM error bars. * indicates a
600 significantly faster completion time compared to SP-UP ($P < 0.05$). \yen indicates significantly
601 faster completion time compared to SP-UP and AO-UP ($P < 0.05$).

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